CLAIMS

What is claimed is:

1. An Exhaust Gas Recirculation (EGR) system providing a mixture of exhaust gas and intake air to the intake of an internal combustion engine, the system comprising a turbocharger including a compressor with more than one stage.

2. The EGR system of claim 1 wherein intake air is compressed in at least one first stage of the compressor, and a mixture of intake air and exhaust gas is compressed in at least one second stage of the compressor.

3. The EGR system of claim 2 wherein the compressor has two stages.

4. The EGR system of claim 2 wherein the turbocharger is a variable geometry turbocharger.

5. The EGR system of claim 2 further comprising a control valve which determines the proportion of exhaust gas produced by the engine to be recirculated.

6. The EGR system of claim 2 further comprising an EGR mixer to mix the exhaust gas with intake air to form the mixture.

7. The EGR system of claim 6 wherein the intake air is compressed by at least one first stage of the turbocharger to achieve a first intermediate pressure, the first intermediate pressure being less than an intake pressure at an intake manifold of the engine, and wherein back pressure from a turbocharger turbine maintains a pressure of the exhaust gas at a second intermediate pressure, the second intermediate pressure being less than an intake pressure at an intake manifold of the engine.

8. The EGR system of claim 1 wherein the turbocharger comprises:

a case having a turbine housing receiving exhaust gas from an exhaust manifold of an internal combustion engine at an inlet and having an exhaust outlet, a

compressor housing having an air inlet and a first volute, and a center housing intermediate the turbine housing and compressor housing;

a turbine wheel carried within the turbine housing and extracting energy from the exhaust gas, said turbine wheel connected to a shaft extending from the turbine housing through a shaft bore in the center housing;

a bearing supported in the shaft bore of the center housing, said bearing supporting the shaft for rotational motion;

a compressor impeller connected to the shaft opposite the turbine wheel and carried within the compressor housing, said compressor impeller having a first plurality of impeller blades mounted on a front face proximate the air inlet, said first plurality of blades increasing the velocity of air from the air inlet and exhausting air into the first volute, said compressor impeller also having a second plurality of impeller blades mounted on a back face, said second plurality of blades increasing the velocity of air from a scroll inlet connected to the first volute, and exhausting air into a second volute having a charge air outlet connected to the engine intake, said scroll inlet and second volute integral to the case intermediate said compressor housing and turbine housing.

9. The EGR system of claim 8 wherein the second plurality of impeller blades compresses the mixture to a pressure required by the engine to transit a desired mass flow.

10. The EGR system of claim 9 further comprising a diesel particulate filter to filter the exhaust gas before the exhaust gas enters the first plurality of blades.

11. The EGR system of claim 2 further comprising at least one cooler.

12. The EGR system of claim 2 further comprising at least one emissions control device.

13. An EGR system for an internal combustion engine wherein a turbocharger maintains a pressure of exhaust gas at an intermediate pressure lower than a pressure at an intake manifold of the engine, wherein said intermediate pressure is greater than a

pressure of intake air, the intake air having been compressed by a first stage of a two stage compressor.

14. The EGR system of claim 13 wherein the compressor forms a part of a turbocharger.

15. The EGR system of claim 14 wherein the exhaust gas and the intake air are mixed together to form a mixture, and the mixture is further compressed by a second stage of the two stage compressor until the mixture reaches a pressure sufficient to meet a mass flow demand of the engine.

16. A method of providing exhaust gas recirculation to an internal combustion engine comprising the steps of:

maintaining a pressure of exhaust gas produced by the engine at a first intermediate pressure less than a pressure at an intake manifold of the engine;

increasing a pressure of intake air to a second intermediate pressure;

mixing the exhaust gas and intake air to form a mixture; and

boosting the pressure of the mixture to a pressure sufficient to meet a mass flow demand of the engine.

17. The method of claim 16 wherein the maintaining step comprises using back pressure from a turbocharger turbine.

18. The method of claim 16 wherein the maintaining step further comprises filtering the exhaust gas.

19. The method of claim 16 wherein the increasing step comprises compressing the intake air with a first stage of a two stage compressor.

20. The method of claim 16 wherein the boosting step comprises compressing the mixture using the second stage of a two stage compressor of a turbocharger, wherein the turbocharger comprises:

a case having a turbine housing receiving exhaust gas from an exhaust manifold of an internal combustion engine at an inlet and having an exhaust outlet, a compressor housing having an air inlet and a first volute, and a center housing intermediate the turbine housing and compressor housing;

a turbine wheel carried within the turbine housing and extracting energy from the exhaust gas, said turbine wheel connected to a shaft extending from the turbine housing through a shaft bore in the center housing;

a bearing supported in the shaft bore of the center housing, said bearing supporting the shaft for rotational motion;

a compressor impeller connected to the shaft opposite the turbine wheel and carried within the compressor housing, said compressor impeller having a first plurality of impeller blades mounted on a front face proximate the air inlet, said first plurality of blades increasing the velocity of air from the air inlet and exhausting air into the first volute, said compressor impeller also having a second plurality of impeller blades mounted on a back face, said second plurality of blades increasing the velocity of air from a scroll inlet connected to the first volute, and exhausting air into a second volute having a charge air outlet connected to the engine intake, said scroll inlet and second volute integral to the case intermediate said compressor housing and turbine housing.